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A Wild Magcargo Appeared!

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Abstract
There are many Pokémon with unique characteristics that are not just impossible for a living organism but would have serious physical consequences. Magcargo is one such Pokémon that is being investigated in this paper. Its internal temperature of 18,000 °F would not only be extremely harmful to surrounding organisms, but a sudden appearance would most likely kill any person before they knew what had happened.

Introduction

Magcargo is a small (0.79 m) amorphous Lava Pokémon with the national Pokédex number 219. Its appearance is that of a snail, but with a bright red body composed of magma. Its shell is composed of grey, hardened magma that is very brittle and breaks upon the slightest touch. The internal temperature of Magcargo is roughly 18,000 °F that causes water to evaporate on contact. It can reform its body by dipping itself in magma[1]. The aim of this article is to investigate the effect of Magcargo and the effect on the average human if "A wild Magcargo appeared!" based on a YouTube video "3 Pokémon who could kill you" by VSauce [2].

Temperature

The internal temperature of Magcargo is 18,000 °F or 10,255 K, which is nearly twice as hot as the surface temperature of the sun (6,000K)[2].

There are 3 modes in which heat can be transferred: Conduction, convection and radiation. For simplicity, this paper models the outside temperature to be the same as the internal temperature. Assuming that Magcargo has a spherical body with a radius of $0.395\,m$ gives surface area of $1.96\,m^2$. Its natural environment would mostly transfer heat through air convection and radiation (conduction does not apply to fluid like medium). Convectional heat dissipates very quickly in an open environment, such as the natural habitat of Magcargo. Thus, most of the heat transfer is through radiation which can be calculated using the Stefan-Boltzmann equation:

$$\frac{Q}{\Delta t} = \varepsilon\sigma A(T^4 - T_0^4),$$

where ε is the emissivity of the medium, A is the area, σ is the Stefan-Boltzmann constant ($5.67 \times 10^{-8} W\,m^{-2}\,K^{-4}$)[3], T is the source temperature and T_0 is the environmental temperature.

The lowest limit of emissivity of lava is 0.5[4] and using the Stefan-Boltzmann equation this results in a transfer of $6.15\text{x}10^8$ W to its surroundings (see below).

$$\frac{Q}{\Delta t} = (0.5)(\sigma)(1.96m^2)(10{,}255\mathrm{K}^4 - 313.15\mathrm{K}^4)$$
$$= 6.145 \times 10^8\ W$$

Assuming the specific heat capacity of air is $1.0\ kJ\ kg^{-1}\,K^{-1}$ and the density of air is $1.127\ kg\ m^{-3}$[2], the temperature of air around Magcargo in a 10m radius (of an isolated system) would increase by:

$$mass\ of\ air{:}\ density\ \times volume$$
$$= (1.127\ kg\ m^{-3})\left(\frac{4}{3}\pi(10m)^3\right)$$
$$= 4{,}721\ kg$$

$Temperature\ change$:
$$\frac{6.145 \times 10^5\ kJ\ s^{-1}}{(1.0\ kJ\ kg^{-1}\ K^{-1})(4{,}721\ kg)} = 130\ Ks^{-1}$$

At the highest possible emissivity of lava (black body = 1)[4], the energy emission and temperature change will double. While heat in the atmosphere dissipates very quickly, the amount of heat that Magcargo radiates will nevertheless heat the surrounding air to relatively high temperatures.

Magcargo and the human body

If a Magcargo does appear suddenly at a distance of 10 m from the observer, then a lot of the energy would be absorbed by the human body. For a human with a height of 1.8 m and width of 0.5 m, the exposed surface area of the observer facing towards the Pokémon is 0.9 m^2. Since the rate of heat transfer is uniform in all directions from a spherical source, a sphere of heat surrounding the source would be produced. If the human is stood at a 10m distance, the area of this sphere would be:

$$4\pi(10m)^2 = 1256.6\ m^2.$$

The human would take up 7.16×10^{-4} of the sphere's area as:

$$\frac{0.9\ m^2}{1256.6\ m^2} = 7.16 \times 10^{-4}$$

The proportional amount of heat transfer to the human would therefore be:

$$6.145 \times 10^8 W \times 7.16 \times 10^{-4} = 4.4 \times 10^5\ W.$$

The average specific heat capacity of the human is 3.57 kJ kg^{-1} K^{-1} [5]. Assuming that the same human has a mass of 65kg, $4.4 \times 10^5 W$ would heat him up at a rate of:

$$440\ kJ\ s^{-1} / \ (3.57\ kJ\ kg^{-1}\ K^{-1} \times 65kg) = 1.9Ks^{-1}.$$

With such a high temperature change, a human would die instantly. At highest emissivity, Magcargo would heat up the body twice as fast and blood at body temperature will start to boil within 17 seconds.

Conclusion

The magnitude of the hazard of Magcargo certainly should not be underestimated, but the video[2] overestimates in saying "anything within 50 metres would burst into flames", which would only be true for easily burnable objects standing at such distances for a long periods of time. It produces between 600 MW and 1.2 GW of power in through heat radiation that can heat the surrounding air by hundreds of degrees within a very short time. Magcargo travels very slowly and a heat gradient will be produced away from it, allowing its presence to be felt beyond hazardous distances before coming to close, which should give enough time to avoid confrontation. If a Magcargo does appear suddenly in front of you, at a far enough distance, the body might survive long enough to escape. The distance depends on the absorptivity and heat resistance of the body and is open for further investigation. Nevertheless, distances around 10m and closer would kill a normal human very quickly.

References

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